(AD)

PATENT SPECIFICATION

DRAWINGS ATTACHED

831,118

Date of Application and filing Complete Specification Dec. 30, 1955.

No. 37520/55.

Application made in Germany on Dec. 31, 1954.

Complete Specification Published March 23, 1960.

Index at acceptance:—Classes **1(1)**, A3A1X, C, F(4C:4D:20); **1(2)**, B1A; **2(3)**, C1G(1A2:1D:6A1); **86**, C19A2; **and 123(3)**, G7.

International Classification:—**B01j. C01b. C07c. F22g.**

COMPLETE SPECIFICATION

Method of and apparatus for Carrying out Exothermic Chemical Reactions involving Gases and/or Liquids

We, FARBWERKE HOECHST AKTIENGESELL- [illegible] VORMALS MEISTER LUCIUS & BRÜN- to prevent the flame blowing back with the usual forms of burners. [illegible] are avoided by

ERRATUM

SPECIFICATION NO. 831,118

Page 2, line 119, *for* "hylrogen" *read* "hydrogen"

THE PATENT OFFICE,
9th June, 1960

DS 76086/2(7)/3966 200 5/60 PL

hydrocarbons, are so strongly exothermic that they take place with the partial formation of a flame. In carrying out such reactions industrially the material of which the wall of the reaction vessel is composed is of paramount importance. In order to obtain the thorough intermixing of the reaction components which is necessary for securing a complete reaction, it has been customary to mix the reaction components together in a suitably formed nozzle (burner), so that the reaction occurs in a flame extending into the free space beyond the nozzle. The walls of the reaction chamber must be kept cool, and for this purpose they are cooled externally.

This method of operation has the following main disadvantages:—

(1) The heat taken up by the cooling medium cannot usually be usefully recovered.

(2) In order to attain the pressure necessary for effective mixing of the reaction components, which are usually derived from gasometers in which the pressure is low, blowers or compressors must generally be used.

(3) Costly measures are necessary in order [illegible] direction at the first-mentioned end thereof.

Preferably the gaseous reaction component which is introduced tangentially to form a vortex near the wall of the chamber is the reaction component which is least aggressive towards the material of which the wall is composed.

Specification No. 760,610 describes and claims a tubular mixing chamber comprising means to feed said chamber at one end with a first fluid in such a manner that said fluid flows along the wall of said chamber with tangential and axial velocity components to the other end of said chamber thereby to create at said one end a negative pressure gradient from said wall towards the axis of the chamber, a terminal rigid obstacle at said other end to establish across the section of said other end a distribution of pressure more uniform than at said one end, whereby a substantially axial counterflow is created which extends from said other end to said one end, and whereby a tubular turbulent mixing zone is created by the interaction between said flow and said counterflow, means to feed said

Fig. 1.

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International Classification:—B01j. C01b. C07c. F22g.

COMPLETE SPECIFICATION

Method of and Apparatus for Carrying out Exothermic Chemical Reactions involving Gases and/or Liquids

We, FARBWERKE HOECHST AKTIENGESELLSCHAFT VORMALS MEISTER LUCIUS & BRÜNING, a body corporate recognised by German law, of Frankfurt (M)-Höchst, Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

Many chemical reactions are known which are strongly exothermic and therefore necessitate specially constructed apparatus in order to make the processes industrially feasible. Many of these reactions, for example, the combination of chlorine and hydrogen to form hydrogen chloride, the reaction of oxygen and hydrogen to form steam, and the chlorination of hydrocarbons to form various chlorinated hydrocarbons, are so strongly exothermic that they take place with the partial formation of a flame. In carrying out such reactions industrially the material of which the wall of the reaction vessel is composed is of paramount importance. In order to obtain the thorough intermixing of the reaction components which is necessary for securing a complete reaction, it has been customary to mix the reaction components together in a suitably formed nozzle (burner), so that the reaction occurs in a flame extending into the free space beyond the nozzle. The walls of the reaction chamber must be kept cool, and for this purpose they are cooled externally.

This method of operation has the following main disadvantages:—

(1) The heat taken up by the cooling medium cannot usually be usefully recovered.

(2) In order to attain the pressure necessary for effective mixing of the reaction components, which are usually derived from gasometers in which the pressure is low, blowers or compressors must generally be used.

(3) Costly measures are necessary in order to prevent the flame blowing back with the usual forms of burners.

The aforesaid disadvantages are avoided by the present invention which provides a method of carrying out exothermic chemical reactions between a gas and a fluid, wherein a gaseous reaction component is introduced tangentially at or near one end of a reaction chamber at a velocity such as to form a travelling vortex near the wall of the chamber and at the same time the other reaction component or components is introduced or are introduced separately or in admixture in an axial or tangential direction at the opposite end of the chamber in such manner that the exothermic reaction takes place in the mixing zone in the axial region of the chamber out of contact with the wall thereof, and the reaction components formed leave the chamber in an axial direction at the first-mentioned end thereof.

Preferably the gaseous reaction component which is introduced tangentially to form a vortex near the wall of the chamber is the reaction component which is least aggressive towards the material of which the wall is composed.

Specification No. 760,610 describes and claims a tubular mixing chamber comprising means to feed said chamber at one end with a first fluid in such a manner that said fluid flows along the wall of said chamber with tangential and axial velocity components to the other end of said chamber thereby to create at said one end a negative pressure gradient from said wall towards the axis of the chamber, a terminal rigid obstacle at said other end to establish across the section of said other end a distribution of pressure more uniform than at said one end, whereby a substantially axial counterflow is created which extends from said other end to said one end, and whereby a tubular turbulent mixing zone is created by the interaction between said flow and said counterflow, means to feed said

chamber with at least a second fluid to be mixed with said first fluid and means to discharge the mixture of said fluids obtained in said chamber.

The method of the invention and the apparatus for carrying out the method are further described with reference to the accompanying drawings, in which Figures 1 to 3 show various forms of reaction chambers. The positions of the chambers in space need not be as shown in the drawings. Thus, they may be disposed with their axes in an inclined or horizontal plane, or in a vertical plane with their bases lowermost, instead of uppermost as shown in the drawings.

The method of introducing the reaction components in accordance with the present invention very effectively screens the greater part of the interior wall of the recation chamber from the heat liberated in the reaction and the corrosive action of the reaction products or of the more aggressive reaction component. The flow of the reaction components produced in the method of this invention entails a low pressure prevailing in the region U where the tangentially whirling reaction component changes direction. Accordingly, the second reactant, which is introduced at B, may be introduced under no or only a low presure in order to ensure intense mixing of the two reactants in the mixing zone above the point of reversal U. The reaction takes place in the whirling central stream substantially along the path B—C, where further mixing of the components proceeds continuously. The radiant heat liberated by the reaction is not transferred directly to the wall of the reaction chamber, but is transferred first to the whirling stream of the reaction component introduced tangentially at A, so that this reaction component is heated up during is travel from A to U. In this manner the reaction component attains its highest temperature where, in its whirling motion, it mixes in the mixing zone above the point of reversal U with the other reaction component which is introduced, if desired, cold, from B. Consequently, ignition of the mixture takes place reliably and continuously, and heat produced by the reaction can be put to good account due to the adiabatic character of the exothermic process. The heat so generated is contained in the stream of the reaction product leaving the reaction chamber at C, and can therefore be subsequently recovered almost completely, for example, in a waste heat boiler.

If the temperature required for a certain reaction is below the temperature which can be reached by the adiabatic process, the desired reaction temperature can be obtained by introducing one of the reaction components in large excess or diluted with an inert gas or vapour, which does not enter into reaction but establishes the desired reaction temperature by abstracting a part of the heat of reaction. In both cases the whole of the heat liberated by the reaction is contained in the stream of the reaction product leaving the reaction chamber and can be utilised in an economical manner.

The method of the invention enables the amount of valuable material required for constructing the apparatus, of which a few examples are shown diagrammatically in Figures 1 to 3, to be considerably reduced.

Figures 1 and 2 show reaction chambers, which are substantially of conical form up to the vertex, and which are provided at the bottom with an axial inlet conduit B for a reaction component and at the top with an axial outlet conduit C for the reaction products, and which has one or more inlet conduits A, D and F leading tangentially and at the desired inclination into the interior of the chamber.

Figure 3 shows an apparatus for carrying out the method, in which apparatus the reaction chamber is substantially of cylindrical form. The inlet and outlet conduits A, B, C and D are arranged in a manner analogous to the conduits shown in the other figures.

In the forms of apparatus shown in the accompanying drawings it is only necessary, for example when the outlet temperature of the reaction products is 1100° C., to construct the outlet conduit C of refractory and corrosion-resistant material, while all the other parts of the reaction chamber can be made of ordinary sheet iron. It might, however, be desirable also to construct the walls surrounding the mixing and reaction zone in the vicinity of the point U of resistant material.

Insulation of the apparatus is also a simple matter, because, owing to the whirling flow of the components, the side wall of the reaction chamber remains relatively cool, so that there is a relatively small temperature drop from the inner wall of the chamber to the surrounding space.

When more than two reaction components are to take part in the reaction, a separate inlet conduit, for example, the conduit D, may be provided for the third and any further component. The axial outlet conduit C may be surrounded by a cylindrically arranged tube of larger diameter, which is spaced from the tube C within the reaction chamber, and may be a tube such as is shown at E in Figure 2, the third reaction component being introduced through an inlet conduit F tangentially at a desired inclination so as to whirl round the inner side of the said tube. In this manner there is produced a second vortex which travels in a path parallel with the first vortex of the component introduced at A moving along the wall of the reaction chamber, and which second vortex also changes direction at the point U. Spontaneous mixing of all the components introduced through F, A and B therefore takes place in the mixing zone at the

point U, and then the reaction occurs along the path from B to C.

By suitably selecting the angle of the conical reaction chambers shown in Figures 1 and 2, or by using a cylindrical reaction chamber as shown in Figure 3, the length of the path from B to C can be extended to give the desired period of reaction, without losing the advantages of the method of the invention.

The fundamental principle of the method of this invention can most appropriately be described as reaction control independently of the walls of the chamber. The decisive factor is that by suitably introducing the reaction components along separate paths and intermixing the components only after they have entered the reaction chamber the reaction takes place in an axial zone far removed from the walls of the reaction chamber, so that the precautions which have hitherto been necessary in suitably selecting the properties of the material used for the walls of the apparatus can be dispensed with so far as the greater part of the interior surfaces are concerned.

For reactions which require a catalyst, the catalyst may be arranged in the form of a grid or net close above the point of reversal U, that is to say in the mixing zone, where the reaction components coming from different directions meet. Alternatively, the catalyst may be supported on a short cylindrical tube, which is disposed axially in the reaction chamber along the path from U to C.

The following examples illustrate the method of the invention:—

Example 1

Production of Superheated Steam Having a Desired Temperature

Steam under low pressure is introduced through the inlet A in the apparatus shown in Figure 1 to form a vortex in the reaction chamber, and at the same time hydrogen and oxygen are introduced separately through the inlets B and D. The tangential inlets A and D through which the materials are introduced into the reaction chamber are inclined towards the vertex of the cone at an angle of 85° to the axis of the reaction chamber. The mixture of oxygen with the explosive mixture of hydrogen and oxygen is ignited in the vicinity of the point of reversal U, for example, by means of an electrically heated incandescent candle, so that H_2O is formed and superheated steam is used from the outlet conduit C at a temperature which can be regulated by suitably adjusting the ratio of low pressure steam to explosive mixture, as desired.

Another procedure is previously to mix one of the reaction components, for example, the hydrogen, with the low pressure steam, and to introduce at B the other reaction component, for example, oxygen, through a filter candle, for example, of carborundum. The steam produced by this process can be used as a carrier gas for supplying heat for a wide variety of endothermic reactions, for example, cracking reactions.

This method of obtaining superheated steam has firstly, the advantage of enabling the use of costly refractory materials for the construction of the burner chamber to be dispensed with. Furthermore, variation of the ratio of steam to explosive mixture enables the temperature of the steam to be varied almost instantaneously. Owing to the reduction in heat losses to the exterior owing to the method and apparatus of this invention, the yield of heat amounts to 90—95 per cent of the theoretical yield calculated on the hydrogen introduced. Such a yield of heat cannot even be approximated with externally heated systems.

Example 2

Production of Hydrogen Chloride from Chlorine and Hydrogen

Hydrogen and chlorine are introduced through the inlet conduits A and B of an apparatus as shown in Figure 1, except that it has no inlet conduit D. The inlet conduit A used in the present process is inclined towards the vertex of the cone at an angle of 80° to the axis of the reaction chamber. Ignition is advantageously brought about by means of a connection mounted laterally on the reaction chamber, which connection is closed by a quartz window and through which ultraviolet light is irradiated into the mixing zone above U. The inlet conduit for the chlorine must be made of a material which is resistant to chlorine at moderately raised temperatures and does not lead to the formation of ferric chloride. Furthermore, the outlet conduit C is made of or lined with a material which is resistant to hydrogen chloride at the outlet temperature. Especially suitable is electrographite.

The reaction sets in immediately under the action of the ultraviolet irradiation, and the hydrogen chloride formed leaves through the conduit C at a high temperature. The heat contained in the issuing hylrogen chloride can be used in known manner for generating steam.

WHAT WE CLAIM IS:—

1. A method of carrying out exothermic chemical reactions between a gas and a fluid, wherein a gaseous reaction component is introduced tangentially at or near one end of a reaction chamber at a velocity such as to form a travelling vortex near the wall of the chamber, and at the same time the other reaction component or components is introduced or are introduced separately or in admixture in an axial or tangential direction at the opposite end of the chamber in such manner that the exothermic reaction takes place in the mixing zone in the axial region of the chamber out of contact with the wall thereof, and the reaction components formed leave the chamber in an

axial direction at the first-mentioned end thereof.

2. A method as claimed in Claim 1, wherein the fluid is a gas.

3. A method as claimed in Claim 1 or Claim 2 wherein the gaseous reaction component which is introduced tangentially to form a vortex near the wall of the chamber is the reaction component which is least aggresive towards the material of which the wall is composed.

4. A method as claimed in any one of Claims 1—3, wherein the reaction component introduced at the said opposite end of the chamber is so introduced through a porous candle, which effects wide distribution and assists uniform intermixing.

5. A method as claimed in any one of Claims 1—4, wherein the desired reaction temperature is established by introducing one of the reaction components either in excess or diluted with an inert gas.

6. A method as claimed in any one of Claims 1—5, wherein the reaction takes place with the partial formation of a flame.

7. A method as claimed in any one of Claims 1—6, wherein hydrogen and oxygen are reacted together to form superheated steam, and the temperature is maintained at the desired value by introducing steam.

8. A method as claimed in any one of Claims 1—6, wherein for the production of hydrogen chloride hydrogen is introduced tangentially to form a vortex near the wall of the chamber and chlorine is introduced at the said opposite end of the chamber in the vicinity of the point at which the vortex reverses its direction of travel.

9. A method as claimed in any one of Claims 1—5, wherein hydrocarbons are reacted with chlorine to form various chlorinated hydrocarbons.

10. A method of carrying out an exothermic reaction substantially as described in Example 1 or 2 herein.

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831,118 COMPLETE SPECIFICATION
1 SHEET

This drawing is a reproduction of the Original on a reduced scale.

FIG. 1

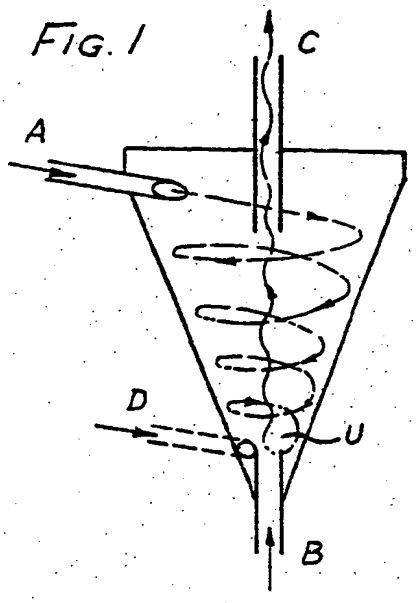

FIG. 2.

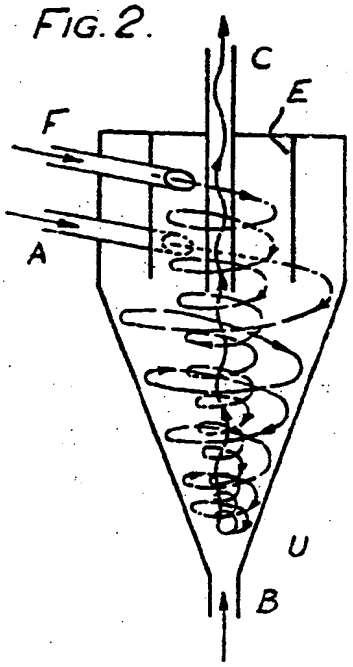

FIG. 3.